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THE METHOD OF PROGRESSION OF SOME LAND OPERCULATES FROM JAMAICA.

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Certain operculate land snails from Jamaica, especially members of the genera *Annularia*, *Colobostylus*, *Tudora*, *Adamsiella* and their allies in the *Ericiidae*, move very rapidly as compared to other land snails of similar size. They are not only rapid in their movements, but erratic; they change the direction of movement abruptly. All are very timid, and quick to contract the body within the shell when disturbed; a shadow thrown on one crawling in the sun is sufficient to cause contraction, and the animal then releases hold of the surface on which it is crawling and drops to the ground. In collecting, it is necessary to avoid startling them by a jar of the surface on which they are progressing, otherwise they instantly fall and are lost in the leaf-covered surface of the ground. This character, no doubt, is a protective one from birds and other enemies, as land crabs, mongoose, etc.

In crawling, when undisturbed, the motion is rapid; but, as noted, its direction may be changed rapidly. This rapid change of direction is possible on account of the shortness of the surface of contact of the foot and also on account of the fact that the actual surface of contact does not involve the whole foot at any time. Observations made upon *Adamsiella variabilis* (C. B. Ad.), *A. ignilabris* (C. B. Ad.), *A. irrorata* Gloyne, *Colobostylus jayanus* (C. B. Ad.), *C. jayanus rufilabris* (C. B. Ad.), *C. banksianus* (Sow.), *C. bronni* (C. B. Ad.), *Tudora armata* (C. B. Ad.), *Annularia fimbriatula* (Sow.) and *Stoustroma pisum* (C. B. Ad.) show that all the above land operculates

possess this type of movement. The method of progression of *Adamsiella irrorata* Gioyne, *Colobostylus bronni* (C. B. Ad.) and *Tudora armata* (C. B. Ad.) has been carefully studied from specimens obtained in Jamaica during the past summer (1910), and an account of their movements will apply in general to all of the above species.¹

Unlike most snails, the *entire* under surface of the foot is not applied to the surface upon which they move, but *they walk on the edges of the foot only*. The foot, when retracted into the shell, folds down the median line of the under surface; and, when protruded for walking, this same form is retained, so that ordinarily only the two outer surfaces are involved. A wave of contraction, lifting a portion of this edge of the foot, proceeds from the posterior to the anterior, the wave moving forward alternately on the two margins of the foot, and with its advance, first on the right side and then on the left, producing a swaying gait that is characteristic of the movement of all the land operculates above enumerated. The wave movement is quite independent in the two sides of the foot, and this is easily seen when the animal is examined from the under side, when crawling over a surface of glass. As the wave passes off at the anterior end of the foot on one side the succeeding wave begins at the posterior end on the other side, and thus the animal acquires the waddling or swaying gait characteristic of this type of movement. As the wave passes off anteriorly a part of the foot is lifted and moved forward; as the wave appears at the posterior end a part of the foot is lifted and moved forward also, so that seen from the front or rear especially, the animal seems to be walking upon stumpy legs, and the movement recalls that of an elephant as seen from the rear. The trail made, when moving over dry surfaces (as the animals normally have to when in their native habitat), is double, only the edges of the foot being involved, and this double trail may always be seen when these snails are actively moving about. The details of the movement in the three species that were especially examined is given below.

Colobostylus bronni (C. B. Ad.), Figure 3. This species is larger

¹ In a recent paper on the mollusca of Mandeville, Jamaica, by Pilsbry and Brown this mode of progression is briefly described as it was observed in *Colobostylus jayanus rufilabris* (C. B. Ad.) and in *Tudora armata* (C. B. Ad.). See Proc. Acad. Nat. Sci., Sept., 1910, p. 522.

than either of the other two examined, the shell measuring 16 mm. in height, with a greatest width of 12 mm. The foot is ashy-gray, the rostrum darker, the eyes black, and the tentacles a bright aurora-red. Its movements, while rapid as compared to ordinary snails, are more deliberate than those of *T. armata* or *A. irrorata*. The length of the foot when crawling is generally 9 or 10 mm.; the width varies from 5 to 4 mm., being narrower when the movement is most rapid. The waves proceed from the posterior to the anterior alternately on either side, requiring about 7 to 8 seconds for the passage of the wave the entire length of the foot, or the wave moves forward about 1.5 mm. per second. The alternate waves on the two lobes of the foot follow each other with an interval of about 5 seconds, or they are 6-7 mm. apart on the two lobes when both waves can be seen together. The rate of progression is quite rapid, varying from 2.5 to 3 mm. per wave, or 12 double waves were observed to advance the animal 70 mm., which is an average rate of progression per minute. The surface of contact of the edge of the foot involved in the movement varies from 1 mm. wide on each side with a median interspace of 2 mm., when moving on dry or dusty surfaces, to 1.5 mm. on each side with a somewhat smaller interspace, when moving on a smooth, non-absorbent surface like glass. The trail is notably double therefore, and the two parallel marks are somewhat irregular in outline.

When moving, the shell is carried balanced on the operculum, and to obtain this balance requires some care on the part of the animal, but once the shell is adjusted to the proper position the animal moves evenly, the shell swaying from side to side from the passage of the alternate waves of contraction of the foot. The balancing of the shell on the operculum was common to all of the three species examined, and undoubtedly it seems to distribute the weight more evenly on the foot, at the same time raising the shell quite clear of the surface on which the animal is moving.

As the foot of this species is large, the character of the wave movement may be readily studied. A part of the edge of the foot is raised from the surface on which the animal is moving, involving in the fold produced about 3 mm., with a clear space of 1 mm. wide, and the fold is usually 2.5 mm. high with a clear opening of more than 1 mm. This hiatus moves forward at the rate of 1.5 mm. per second, and when it reaches the anterior end of the foot this edge is thrust forward as it is raised, so that when it is applied again to the

surface it looks, as has been stated, as though the animal was progressing by steps. This appearance is very striking when the animal is viewed from in front, but when viewed from the rear the regular alternation of the apparent steps strongly recalls the movement of an elephant, as noted above. In either position, the lifting of the edge of the foot as the wave passes off, gives the animal the appearance of advancing by leisurely strides.

Tudora armata (C. B. Ad.). In this species the wave movement is similar to that in *C. bronni*, but it is somewhat more rapid, and the waves follow each other at a shorter interval; nevertheless the forward movement of the shell is slower on account of the shorter wave, being about 50–60 mm. per minute. The foot, when the animal is moving, is about 8 mm. long by 3 to 4 mm. wide; the surface of contact is about 1 mm. on each edge of the foot, with an interspace of some 1 mm. between the two sides of the foot when actively moving. The passage of the wave the entire length of the foot requires about 5 seconds; the alternate waves follow each other every 4 seconds, so that the two waves can generally be seen simultaneously if the moving animal is examined from the under side. Seen in this way the two waves of contraction are about 5 mm. apart, and the form of the foot resembles a swelled barleycorn. In crawling, the shell is balanced on the middle of the operculum, and the swaying gait is even more noticeable than in the last, from the proportionately greater length of the shell, which in this species measures: length, 15 mm.; width, 8 mm. Of course in all cases the first half of the last whorl rests on the operculum. The foot of this species is of a slaty-gray color, the tentacles and rostrum darker, and the eyes black.

Adamsiella irrorata Gloyne, Figures 1 and 2. This species is quicker in its movements than either of the others examined, but the actual distance traversed in unit time is less than in *C. bronni* or *T. armata*. The wave motion is rapid; the wave of contraction traverses the entire length of the foot from back to front in 2 seconds, and the waves follow each other every 3 seconds on each side, or there are 40 waves per minute, 20 on each side. The distance traversed in this time is about 50 mm. The shells vary in size, but the foot is about 7 mm. long when the animal is in motion; its width is about 3–4 mm. As is the case with the other species, the shell is normally carried balanced on the operculum, the round of the penultimate whorl resting in the hollow of the rather small, circular operculum. As this is so

small (3 mm. in diameter) it requires considerable adjustment to get the shell properly balanced upon it, and it usually requires several trials before the shell is finally placed in the proper balance. The animal moves forward until the body is on a strain, then the shell is hitched forward and over the operculum, on which it sometimes catches at the first trial; more often this maneuver has to be repeated several times before the shell is caught in the cup of the operculum. When the balance is finally effected the animal moves steadily away, but with the rocking gait characteristic of the group. This species is excessively timid, closing at the slightest jar, or when a shadow falls upon it, and it then drops from the surface on which it is crawling to the ground, and may lie still for several minutes before the animal is again extended. On the other hand, it is very active and quick in its movements, and liable to change its direction of motion at any point.

In this species the body is of a pale yellowish flesh color, with a darker brownish pigmented mass down the back and running into the rostrum and tentacles. The foot is the same color as the rest of the body that is protruded from the shell.

Comparing the three species upon which exact observations were made, the results may be tabulated as follows:

Comparison of motion of *C. brononii*, *T. fecundum* and *A. irrorata*.

Species.	Waves per minute on a side.	Wave traverses length of foot, seconds.	Distance traversed in 1 minute.	Distance moved per wave.
<i>Colobostylus brononii</i>	12	7-8	70 millimeters.	3 millimeters.
<i>Tudora fecundum</i>	15	5	50-60 "	2 "
<i>Adamsiella irrorata</i>	20	2	50 "	1.25 "

This method of progression is so different from that of most land snails that other land operculates were examined for comparison. A species of *Helicina* (*H. neritella angulata* C. B. Ad.) collected at Montego Bay, Jamaica, from which locality *C. brononii* and *A. irrorata*

were obtained, has been examined as to its method of progression, Figure 4. It is that of the ordinary snail, the under side of the foot being in total contact with the surface over which it moves. Observed from the under side when the animal is actively crawling over a surface of glass, the foot is seen to be extended to a length of 20 mm., or, including the labial tentacles and head segment, 24 mm.; the tentacles may be protruded about 8 mm. more. The foot proper shows a central muscular portion extending its entire length, about 3 mm. wide anteriorly and tapering to less than 1 mm. wide posteriorly; it is bounded for its entire length on each side by an area that corresponds to the edge of the foot on which the above opercules move. This has apparently the structure of the upper surface of the foot and is not involved in the muscular contractions during locomotion; it does not appear to be traversed by the contractile muscles. When the under side of the foot is observed during active motion of the animal, the middle band of the foot is seen to contract in a series of waves which traverse the length of the foot in about 10 seconds, or at a rate of 2 mm. per second. These waves follow each other closely; there are about 50 to 60 waves per minute. They move from the anterior to the posterior end of the foot, in the reverse direction of the wave movement described above for the other species. The foot is not so firm as in the above species, and while the operculum is placed under the shell it does not support it, as in the case of *Colobostylus*, *Tudora* and *Adamsiella*. The motion is perfectly even, rather slow, and of course there is no swaying of the shell from side to side which is so characteristic of the other species described.

The movement of *Stoastoma pisum* (C. B. Ad.) resembles that of the above species of *Colobostylus*, *Tudora*, etc., and it has undoubtedly been observed (though not described), for Chitty gives a figure of this species crawling which shows plainly the raised margin of the foot, due to the passage of the wave. The figure is unaccompanied by any description of this character of the animal.

NOTES ON SOME LAND SNAILS FROM KENTUCKY.

BY V. STERKI.

On September 25th last I had a few hours to look for snails at Maysville, Mason Co., Ky., in the Ohio Valley. The place was the steep northeast slope of a limestone hill and on its top, for the most